Sewerable Water Monitoring

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Introduction

In 2000, the Livermore site discharged an average of 0.97 million liters (ML) per day of wastewater to the City of Livermore sewer system, an amount that constituted 3.9% of the total flow to the system. This volume includes wastewater generated by Sandia National Laboratories/California, which is discharged to the LLNL collection system and combines with LLNL sewage before it is released at a single point to the municipal collection system (**Figure 6-1**). In 2000, Sandia/California generated approximately 16% of the total effluent discharged from the Livermore site. LLNL's wastewater contains sanitary sewage and industrial wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below in the "Pretreatment Discharges" and "Categorical Discharges" sections.

The effluent is treated at the Livermore Water Reclamation Plant (LWRP). As part of the Livermore-Amador Valley Wastewater Management Program, the treated sanitary wastewater is transported out of the valley through a pipeline and discharged into San Francisco Bay. A small portion of this treated wastewater is used for summer irrigation of the municipal golf course adjacent to the LWRP. Sludge from the treatment process is disposed of in sanitary landfills.

LLNL receives water from two suppliers. LLNL's primary water source is the Hetch-Hetchy Aqueduct. Secondary or emergency water deliveries are taken from the Alameda County Flood Control and Water Conservation District Zone 7. This water is a mixture of groundwater and water from the South Bay Aqueduct of the State Water Project. Water quality parameters for the two sources are obtained from the suppliers and are used to evaluate compliance with the discharge permit conditions that limit changes in water quality between receipt and discharge.

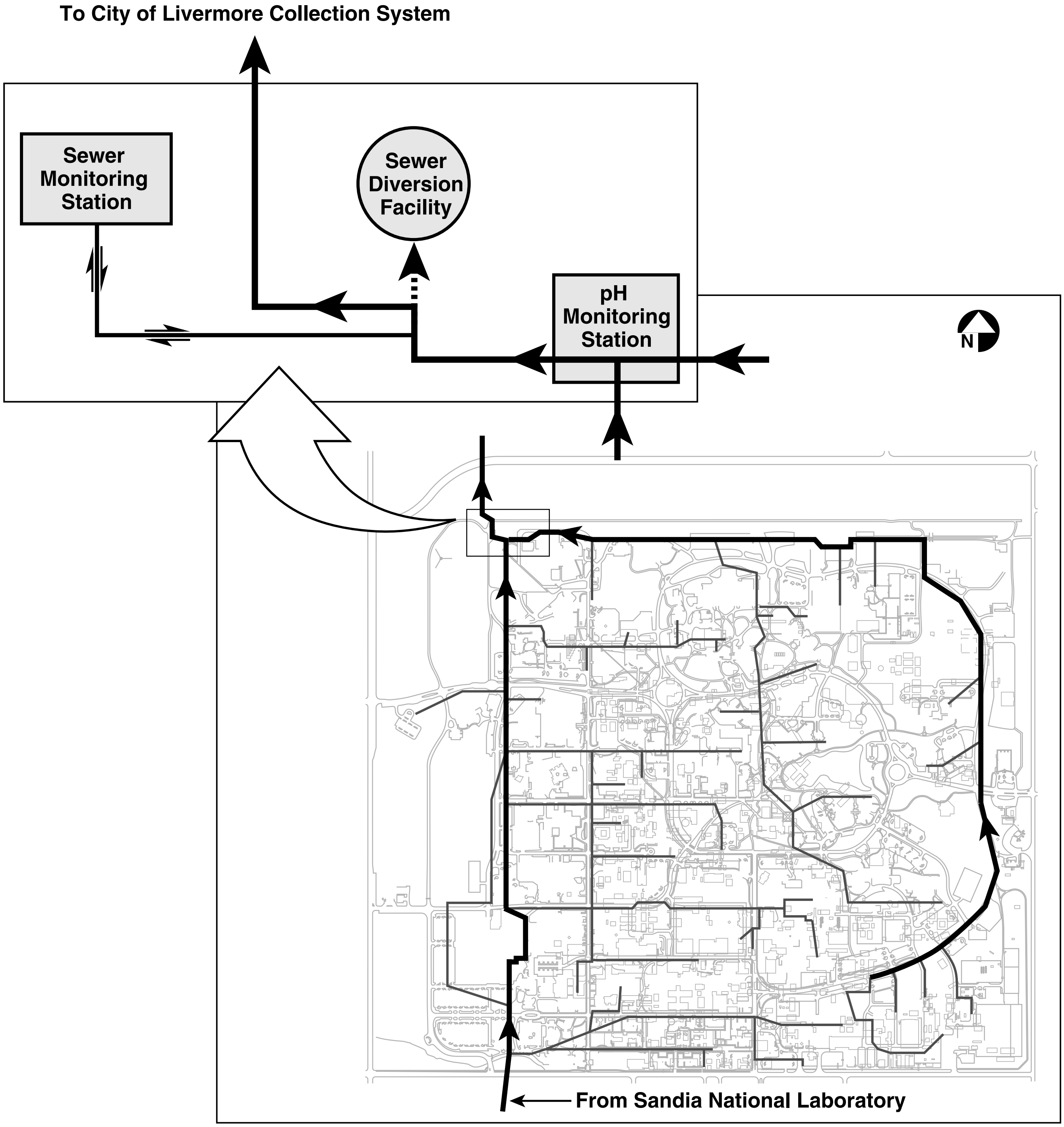

Figure 6-1. LLNL sanitary sewer system, monitoring stations, and diversion facility

Preventive Measures

Administrative and engineering controls at the Livermore site are designed to prevent potentially contaminated wastewater from being discharged directly to the sanitary sewer. Waste generators receive training on proper waste handling. LLNL personnel review facility procedures and inspect processes to ensure appropriate discharges. Retention tanks collect wastewater from processes that might release contaminants in quantities sufficient to disrupt operations at the LWRP. Wastewater that cannot be discharged into one or more of the surface water collection units at LLNL's Experimental Test Site (Site 300) is transported to LLNL's Livermore site and managed under Livermore site retention tank administrative controls. Groundwater (generated from startup operations associated with new, portable groundwater treatment units, tests of experimental treatment units, and maintenance of existing treatment facilities) is analyzed for pollutants of concern and must meet permitted criteria, or LWRP approval must be obtained before it can be discharged to the sanitary sewer. Finally, to verify the success of training and control equipment, wastewater is sampled and analyzed not only at the significant points of generation, as defined by type and quantity of contaminant generated, but also at the point of discharge to the municipal sewer system.

For facilities with installed retention tank systems, collected wastewater is discharged to the sanitary sewer only if analytical laboratory results show that pollutant levels are within allowable limits (Grandfield 1989). LLNL developed internal discharge guidelines for specific sources and operations to ensure that sewer effluent for the entire site complies with LLNL's wastewater discharge permit. Process wastewater generation and discharge frequency from retention tanks vary from monthly to yearly, depending upon the process. During 2000, there were approximately 33 waste retention tank systems in use at the Livermore site, with an average of nine wastewater retention tanks discharged each month, averaging a volume of 8200 L per tank.

Table 6-1 shows LLNL's internal discharge guidelines for wastewater discharged to the sewer. Any processes that discharge to the sanitary sewer are subject to the general pretreatment self-monitoring program specified in the Wastewater Discharge Permit issued by the LWRP and, as such, are managed by LLNL using these internal discharge guidelines as applied at the point of discharge into the LLNL sewer.

If pollutant levels exceed internal permissible concentrations, the wastewater is treated to reduce pollutants to the lowest levels practical and below LLNL guidelines, or it is shipped to an off-site treatment or disposal facility. Liquids containing radioactivity are handled on site and may be treated using processes that reduce the activity to levels well below those required by DOE Order 5400.5, or they are shipped to an off-site treatment or disposal facility.

For the year as a whole, the monitoring data reflect the success of LLNL's discharge control program in preventing any adverse impact on the operations of Livermore's treatment plant and are generally consistent with past values.

Monitoring

Monitoring at the Sewer Monitoring Station

LLNL's sanitary sewer discharge permit requires continuous monitoring of the effluent flow rate and pH. Samplers collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, toxic chemicals, and water-quality parameters. In addition, as a best management practice, the outflow to the municipal collection system is sampled

Table 6-1. LLNL's internal discharge guidelines for pollutants in wastewater

Nonradioactive pollutants in wastewaters	
Constituent	**Discharge guidelines**
Metals (mg/L)	
Arsenic	0.06[a]
Cadmium	0.9
Copper	10
Chromium (total)	4.9
Lead	4.9
Mercury	0.05
Nickel	5
Silver	1
Zinc	15
Cyanide (mg/L)[b]	5
Oil and grease (mg/L)	500
Total toxic organics (TTO) (mg/L)[c]	4.57
pH (pH units)	5–10

Radioisotopes in wastewaters[d]		
Parameter	**Individual discharge**	**Total daily limit for site**
Gross alpha	11.1 Bq/L (300 pCi/L)	185 kBq (5.0 μCi)
Gross beta	111 Bq/L (3000 pCi/L)	1.85 MBq (50.0 μCi)
Tritium	185 kBq/L (5.0 μCi/L)	3.7 GBq (100.0 mCi)

a No specific internal discharge limit was developed for this constituent; therefore, the discharge limit in LLNL's wastewater discharge permit is used as a guideline for this parameter.

b Limits apply to cyanide discharges other than cyanide salts. Cyanide salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

c Total toxic organics are defined by the Livermore Municipal Code as the sum total of all detectable organic compounds that are on the Environmental Protection Agency's (EPA's) current priority pollutant list and that are present in concentrations of 0.01 mg/L or greater. Analysis of samples using EPA Methods 624 and 625 satisfies this requirement. A listing of the specific compounds included may be found in the Data Supplement, Chapter 6.

d There is no gross gamma limit; DOE Order 5400.5 isotope-specific limits apply.

continuously and analyzed in real time for conditions that might upset the LWRP treatment process or otherwise impact the public welfare. The effluent is continuously analyzed for pH, regulated metals, and radioactivity. If concentrations above warning levels are detected, an alarm is registered at the LLNL Fire Dispatcher's Station, which is attended 24 hours a day, and the site effluent is diverted to the Sewer Diversion Facility (SDF). The monitoring system provides a continuous check on sewage control, and the LWRP is notified of contaminant alarms. Trained staff respond to all alarms to evaluate the cause and take appropriate action.

Monitoring at the Upstream pH Monitoring Station

In addition to the continuous monitoring at the Sewer Monitoring Station (SMS), LLNL monitors pH at the upstream pH Monitoring Station (pHMS) (see **Figure 6-1** for a system diagram). The pHMS continuously monitors pH between 7 a.m. and 7 p.m. during the work week and diverts pH discharges outside the permitted 5 to 10 range to the SDF. The pHMS duplicates the pH monitoring and diversion capabilities of the SMS, but because it is located upstream of the SDF it is able to initiate diversion earlier. Earlier detection allows LLNL to divert all of the unpermitted site effluent.

Diversion System

LLNL operates and maintains a diversion system that activates automatically when either the SMS continuous monitoring system or the pHMS sounds an alarm. For SMS-activated alarms, the SDF ensures that all but the first few minutes of the potentially affected wastewater flow is retained at LLNL, thereby protecting the LWRP and minimizing any required cleanup. During pH excursions activated by the pHMS, even the first few minutes of affected wastewater flow are retained.

Up to 775,000 L of potentially contaminated sewage can be held pending analysis to determine the appropriate handling method. The diverted effluent may be returned to the sanitary sewer (if it meets LLNL's wastewater discharge permit limits), shipped for off-site disposal, or treated at LLNL's Hazardous Waste Management (HWM) Facility. The majority of all diverted sewage in 2000 was returned to the sanitary sewer.

Pretreatment Discharges

The general pretreatment regulations establish both general and specific standards for the discharge of prohibited substances (40 CFR 403.5) that apply to all industrial users. These regulations apply even if LLNL is subject to other federal, state, or local pretreatment standards. The pretreatment standards contain prohibitions intended to protect the LWRP and its operations from interference with its treatment processes or pass-through that would cause the LWRP to violate its own effluent limitations. The LWRP, under the authorization of the San Francisco Bay Regional Water Quality Control Board (SFBWQCB), requires self-monitored pretreatment programs at both the Livermore site and Site 300. The sampling and monitoring of nondomestic, industrial sources covered by pretreatment standards defined in 40 CFR 403 are required in the 2000-2001 Wastewater Discharge Permit No. 1250 issued for the discharge of wastewater from LLNL into the City of Livermore sewer system. Permit 1250 lists all the self-monitoring parameters that are applied at the SMS before wastewater enters the municipal collection system at LLNL's effluent outfall (see **Figure 6-1**). Parameters with numerical limits are listed in **Table 6-2**. The additional discharge limits shown in **Table 6-2** are discussed in the "Categorical Discharges" and "Discharges of Treated Groundwater" sections. Other required parameters such as flow rate, biological oxygen demand, total dissolved solids, total suspended solids, and tributyltin are also monitored at the SMS but have no specific numerical limits.

In 2000 and early 2001, LLNL received a total of three Notices of Violation (NOVs) from the LWRP for exceeding permit limits in 2000. The first was for discharging wastewater that exceeded the effluent discharge limit for cyanide. The second NOV was for an excess of silver above the discharge permit limit. (See the "Nonradioactive Pollutants in Sewage" section of this chapter for more details on these events.) The third NOV received was issued for excess chromium and nickel found during compliance sampling of effluent from a water-jet process. (Details of this event are provided in the "Categorical Discharges" section of this chapter.)

Two additional pieces of correspondence were received from the LWRP for calendar year 2000. One letter, dated January 8, 2001, was in regard to acetone results for compliance sampling of a regulated retention tank on October 19, 2000, and LLNL site effluent on November 7, 2000. Although acetone is not one of the priority pollutants listed for the total toxic organics (TTO) discharge limit, the LWRP letter encouraged LLNL to reduce the concentration of acetone in future discharges because the values LLNL measured in the retention tank and the site effluent were 8900 and 500 µg/L, respectively. As requested, LLNL reviewed the handling and disposal procedures for acetone from processes contributing to the retention tank. The required written response to the LWRP letter was submitted on January 31, 2001.

The other letter, received in March 2000 from the LWRP, requested detailed LLNL tritium discharge data. LLNL provided the requested data in April 2000 as part of an ongoing, joint LLNL and LWRP project to investigate and quantify tritium

Table 6-2. Permit discharge limits for nonradioactive pollutants in LLNL wastewaters

Parameter	Permit discharge limits			
	Permit 1250			Permit 1510G
	Outfall[(a)]	Metal finishing[(b)]	Electric component[(b)]	Treated groundwater
Metals (mg/L)				
Arsenic	0.06	—[(c)]	0.83	0.06
Cadmium	0.14	0.07	—[(c)]	0.14
Chromium (total)	0.62	1.71	—[(c)]	0.62
Copper	1.0	2.07	—[(c)]	1.00
Lead	0.20	0.43	—[(c)]	0.20
Mercury	0.01	—[(c)]	—[(c)]	0.01
Nickel	0.61	2.38	—[(c)]	0.61
Silver	0.20	0.24	—[(c)]	0.20
Zinc	3.0	1.48	—[(c)]	3.00
Organics (mg/L)				
TTO[(d)]	1.00	2.13	1.37	1.00
Other (mg/L)				
Cyanide[(e)]	0.04	0.65	—[(c)]	0.04[(f)]
Oil and grease	100	—[(c)]	—[(c)]	100
pH (pH units)	5–10	—[(c)]	—[(c)]	5–10

a These standards apply at the SMS (the point of discharge to the municipal sewer). All other standards in this table apply at the point of discharge into LLNL's sanitary sewer system.

b Values shown for these categorical standards were specified by EPA. By regulation, the EPA or City of Livermore limit is used, whichever is lower. The internal limits in **Table 6-1** are applied by LLNL where no other standard is specified.

c There is no specific categorical limit for this parameter; therefore, the **Table 6-1** internal discharge limits apply.

d Total toxic organics is defined by the Livermore Municipal Code as the sum total of all detectable organic compounds that are on EPA's current priority pollutant list and that are present in concentrations of 0.01 mg/L or greater. Analysis using EPA Methods 624 and 625 satisfies this requirement. A listing of the specific compounds included may be found in the Data Supplement, Chapter 6.

e Limits apply to cyanide discharges other than cyanide salts. Cyanide salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

f Although Permit 1510G lists a discharge limit for cyanide, sample collection is not required by the self-monitoring program.

in the LWRP liquid effluent. LLNL efforts for this project in the year 2000 included providing the LWRP with technical input and low-level chemical analysis for tritium.

Categorical Discharges

The Environmental Protection Agency (EPA) publishes categorical standards as regulations separate from the general pretreatment regulations and developed for broad categories of specific industrial processes determined to be the most significant contributors to point-source water pollution. These standards contain specific numerical limits for the discharge of industry-specific pollutants from individual processes. The number of processes at LLNL using these pollutants is subject to change as programmatic requirements dictate. During 2000, the LWRP identified 17 specific LLNL wastewater-generating processes that fall under the definition of two categorical standards: Electrical and Electronic Components (40 CFR 469), and Metal Finishing (40 CFR 433). The discharge limits for these standards are shown in **Table 6-2**. Under the terms in Permit 1250, only those processes that discharge to the sanitary sewer require sampling, inspection, and reporting. Three of the 17 identified processes meet these criteria. In 2000, LLNL analyzed samples for all regulated parameters from these three processes and, with one exception, demonstrated compliance with all Federal Categorical Discharge limits.

The first of the three categorical processes that discharge directly into the sanitary sewer system is an abrasive jet machine (or water-jet) that is regulated under the Metal-Finishing Point Source Category; the filtered water from this process is discharged to the sanitary sewer. In January 2001, LLNL received a Notice of Violation from the LWRP for discharging wastewater from this process with concentrations of chromium and nickel in excess of established Federal Pretreatment Categorical Limits on November 2, 2000; split samples of the process wastewater showed concentrations of 14.0 and 8.2 mg/L for chromium and 4.9 and 3.6 mg/L for nickel. After changes to the process, follow-up sampling conducted on January 18 and February 1, 2001, demonstrated a return to compliance. The LWRP conducted a corrective action review and determined that no fines or penalties were required.

The other two discharging categorical processes are both regulated under the Federal Electrical and Electronic Component Point Source Category. One is a series of processes clustered within a single building that houses research-scale microfabrication laboratories used for developing prototype semiconductor devices. These laboratories discharge into a building wastewater retention system, and because they are housed within the same building with no diluting flow, they share a single point of compliance. The other categorical process is a small gallium arsenide cutting operation; this process discharges directly to the sanitary sewer.

The nondischarging processes, all regulated under the Metal-Finishing Point Source Category (40 CFR 433), were printed circuit board manufacturing, electrolysis plating, chemical etching, electroplating, anodizing, coating, painting, cleaning, electrical discharge machining, irridite processing, and abrasive jet machining (water-jet). The wastewater from these processes was contained for removal and off-site shipment by LLNL's Hazardous Waste Management Division (HWM).

Discharges of Treated Groundwater

LLNL's groundwater discharge permit (1510G, 2000) allows treated groundwater from site-wide cleanup activities under the Comprehensive Environmental Response, Compensation and Liability

Act (CERCLA) of 1980 to be discharged in the City of Livermore sanitary sewer in compliance with **Table 6-2** effluent limitations taken from the Livermore Municipal Code.

During 2000, the volume of groundwater discharged to the sanitary sewer was approximately 18,556 L. Water discharges during this period were related to well purging and maintenance of an existing treatment facility (TFD). Three separate discharges were sampled and discharged to the sewer during this period, all in compliance with self-monitoring permit provisions and discharge limits of Permit 1510G. Monitoring data are presented in the Data Supplement, Chapter 6.

Radioactive Pollutants in Sewage

Monitoring Results

LLNL determines the total radioactivity released from tritium, alpha emitters, and beta emitters based either on the measured radioactivity in the effluent or on the limit of sensitivity, whichever is higher (see **Table 6-3**). The 2000 combined releases of alpha and beta sources was 0.28 GBq (0.0076 Ci). The combined total is based on the alpha and beta results shown in **Table 6-3**. The tritium total was 5.0 GBq (0.14 Ci), and the annual mean concentration of tritium in LLNL sanitary sewer effluent was 0.014 Bq/mL (0.38 pCi/mL).

Table 6-3. Estimated total radioactivity in LLNL sanitary sewer effluent, 2000

Radioactive emitter	Estimate based on effluent activity (GBq)[a]	Limit of sensitivity (GBq)
Tritium	5.0	3.9
Alpha sources	0.040	0.033
Beta sources	0.24	0.043

a 37 GBq = 3.7×10^{10} Bq = 1 Ci

Summary results for tritium measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-4**. The monthly tritium numbers are based on the flow-weighted average of the individual daily sample results for a given month. The total annual result is based on the multiplication of each daily sample result or the limit of sensitivity, whichever is greater, by the total flow volume over which the sample was collected, and summing up over all samples. (All other total annual results presented in this chapter for radioactive emitters are also calculated conservatively; the limit of sensitivity or minimum detectable concentration is used to determine the total annual activity when the limit of sensitivity is greater than the sample result.) Also included in the table are fractions of LWRP, Department of Energy (DOE), and 10 CFR 20 limits, discussed in the "Environmental Impact" section.

The historical trend in the monthly average concentration of tritium is shown in **Figure 6-2**. Also included in the figure are the limit of sensitivity (LOS) values for the tritium analysis and the DOE tritium limit (370 Bq/mL), discussed in the "Environmental Impact" section of this chapter. The trend indicates a well-controlled tritium discharge, orders of magnitude below the DOE tritium limit. (Note that for 2000 data, only results above the LOS are plotted.)

The concentrations of plutonium-239 and cesium-137 measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-5**. The plutonium and cesium numbers are the direct results for analyses of monthly composite samples of LLNL and LWRP effluent, and quarterly composites of LWRP sludge. At the bottom of the table, the total annual activity released is given by radioisotope. Also included in the table are fractions of DOE limits, discussed in the "Environmental Impact" section.

Table 6-4. Tritium in sanitary sewer effluents, LLNL and LWRP, 2000

Monitoring results			
	LLNL		LWRP
	Daily	Monthly average	Weekly
Maximum (Bq/mL)	0.107 ± 0.007[a]	0.016[b]	0.0080[c]
Median (Bq/mL)	0.001	0.004	<–0.0004[d]
IQR[e] (Bq/mL)	0.005	0.005	—[d]
LLNL annual total (GBq)	5.0		
Discharge limits for LLNL effluent			
	Discharge limit	Monitoring results as percentage of limit	
		LLNL maximum	LLNL median
LWRP permit daily discharge limit (Bq/mL)	12	0.89	0.0083
DOE annualized discharge limit for application of BAT[f] (Bq/mL)	370	0.0043[g]	0.0011[g]
10 CFR 20 annual total (GBq)	185	2.7	

a This daily result is for a June sample; the detection limit for the analysis was 0.008 Bq/mL. See the Data Supplement, Chapter 6, for all daily results.

b This is the monthly average for February. All year 2000 monthly averages greater than the LOS are plotted in **Figure 6-2.**

c This is a weekly result for a March sample. The result was not above the detection limit (0.011 Bq/mL) for the analysis. None of the LWRP weekly monitoring results were greater than the detection limits for the analyses; a detection limit is the smallest concentration of radioactive material that can be detected with a large degree of confidence. (See Chapter 14.) The detection limits ranged from 0.008 to 0.012 Bq/mL. See the Data Supplement, Chapter 6, for all weekly results.

d Because of the large number of nondetects, the central tendency is reported as less than the median value, and the interquartile range is not calculated. See Chapter 14.

e IQR = Interquartile range

f The DOE annualized discharge limit for application of best available technology (BAT) is five times the derived concentration guide (DCG: ingested water) for each radionuclide released.

g Monitoring results as a percentage of limit are calculated using LLNL monthly average results and the DOE annualized discharge limit.

Figure 6-3 shows the average monthly plutonium and cesium concentrations in sewage since 1991. For 2000, the annual mean concentration of cesium-137 was 2.6×10^{-6} Bq/mL (7.0×10^{-5} pCi/mL); the annual mean concentration of plutonium-239 was 2.7×10^{-7} Bq/mL (7.3×10^{-6} pCi/mL).

Environmental Impact

During 2000, no inadvertent discharges exceeded any discharge limits for release of radioactive materials to the sanitary sewer system.

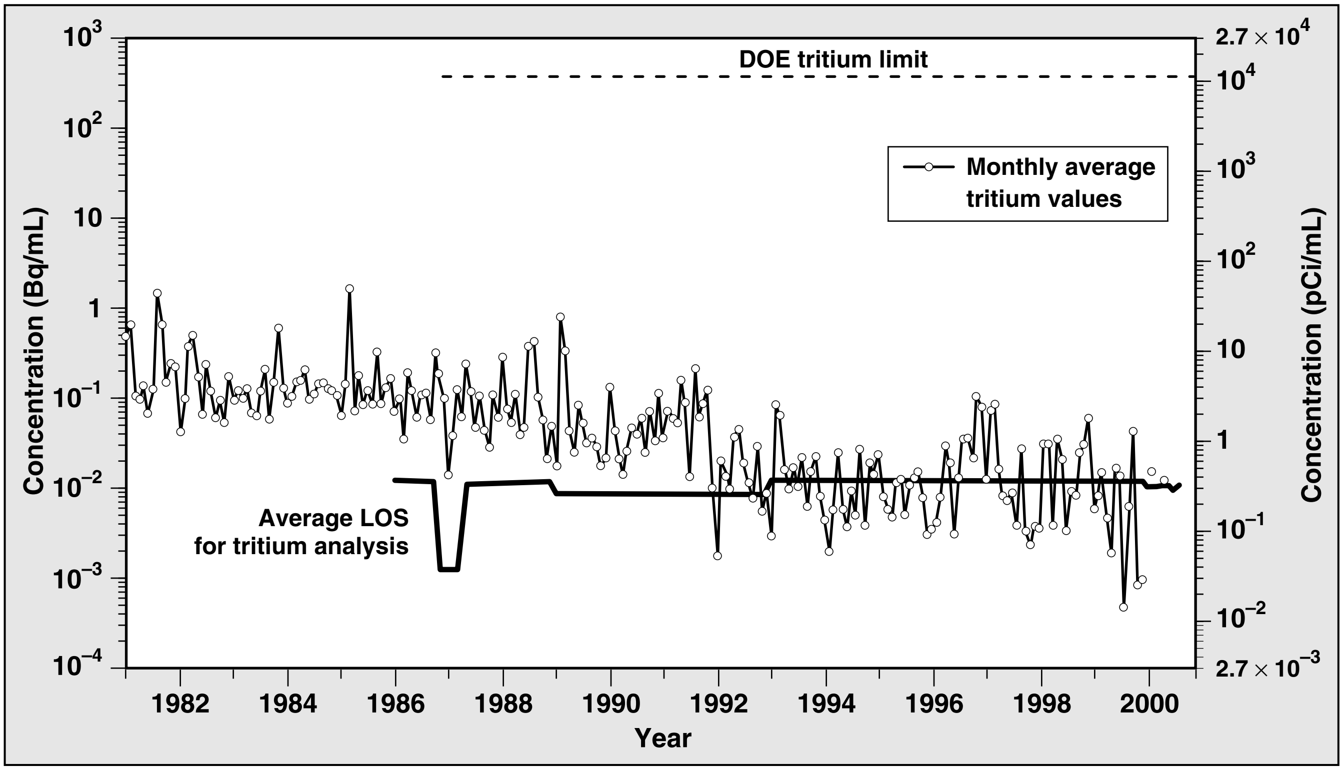

Figure 6-2. Historical trend in tritium concentration in LLNL sewage

In 1999, the Work Smart Standards (WSS) developed for LLNL became effective. Included in the WSS are the standards selected for sanitary sewer discharges. For radioactive material releases, complementary (rather than redundant) sections from DOE Order 5400.5, Radiation Protection of the Public and Environment, and Title 10 of the Code of Federal Regulations, Part 20, are both part of the standards.

From DOE Order 5400.5, the WSS for sanitary sewer discharges include the criteria DOE established for the application of best available technology to protect public health and minimize degradation of the environment. These criteria (the Derived Concentration Guides, or DCGs) limit the concentration of each radionuclide discharged to publicly owned treatment works. If a measurement of the monthly average concentration of a radioisotope exceeds its specific concentration limit, LLNL is required to improve discharge control measures until concentrations are again below the DOE limits. **Tables 6-4** and **6-5** include the DCGs for the specific radioisotopes of most interest at LLNL.

The median monthly average concentration of tritium in LLNL sanitary sewer effluent was 1.1×10^{-5}, that is, 0.0011% of the DOE DCG, and the maximum monthly average concentration of tritium was 4.3×10^{-5} (0.0043%) of the DCG (see **Table 6-4**).

Table 6-5. Cesium and plutonium in sanitary sewer effluents, LLNL and LWRP, 2000

Month	^{137}Cs (μBq/mL)				^{239}Pu (nBq/mL)				^{239}Pu (mBq/dry g)	
	LLNL		LWRP		LLNL		LWRP		LWRP sludge[a]	
	Radio–activity	MDC	Radio-activity	MDC	Radio-activity	MDC	Radio-activity	MDC	Radio-activity	MDC
Jan	2.0 ± 3.0	2.8	0.79 ± 2.61	2.37	278 ± 44	10	–0.47 ± 4.63	11.9		
Feb	–0.94 ± 3.34	2.90	–0.24 ± 2.60	2.29	118 ± 29	6	4.2 ± 5.8	8.1		
Mar	0.31 ± 2.86	2.56	0.33 ± 2.56	2.30	262 ± 45	5	–6.7 ± 5.5	21.3	0.17 ± 0.02	0.00
Apr	2.5 ± 3.1	2.9	–0.29 ± 2.99	2.56	155 ± 29	8	4.1 ± 9.1	12.4		
May	–0.61 ± 3.06	2.61	–0.89 ± 2.46	2.06	142 ± 29	12	0.99 ± 3.67	8.51		
Jun	1.0 ± 2.9	2.6	1.0 ± 2.7	2.4	43.7 ± 19.5	17.5	–2.0 ± 3.8	11.0	0.16 ± 0.03	0.01
Jul	0.24 ± 2.19	2.01	–2.3 ± 2.8	2.4	75.1 ± 18.5	8.7	0.8 ± 10.3	15.3		
Aug	1.1 ± 2.4	2.2	1.6 ± 2.4	2.3	23.6 ± 15.7	15.6	–12.0 ± 9.5	19.1		
Sep	2.3 ± 1.8	2.2	–0.83 ± 2.90	2.57	1550 ± 140	16	–0.88 ± 3.25	8.66	0.080 ± 0.016	0.006
Oct	0.88 ± 2.70	2.52	–0.38 ± 2.63	2.36	297 ± 50	12	–2.1 ± 2.1	8.5		
Nov	1.3 ± 2.9	2.8	–0.08 ± 2.74	2.48	219 ± 32	8	–2.5 ± 6.0	15.6		
Dec	0.39 ± 2.73	2.52	–0.70 ± 2.53	2.25	78 ± 22	12	–5.2 ± 6.7	17.8	2.98 ± 0.16	0.01
Median	<0.9[b]		<–0.3[b]		149		<–1.45[b]		0.17	
IQR[c]	—[d]		—[d]		189		—[d]		0.73	
	pCi/mL[e]								pCi/dry g[e]	
Median	$<2.6 \times 10^{-5}$		$<-7.2 \times 10^{-6}$		4.2×10^{-6}		$<-3.9 \times 10^{-8}$		0.0045	
IQR[c]	—[d]		—[d]		5.1×10^{-6}		—[d]		0.0198	
			Annual LLNL total discharges by radioisotope							
			^{137}Cs				^{239}Pu			
Bq/y			9.1×10^{5}				9.6×10^{4}			
Ci/y			2.5×10^{-5}				2.6×10^{-6}			
			Fraction of limit[f]							
DOE annualized discharge limit[g]			4.6×10^{-6}				7.3×10^{-7}			

Note: Results in this table are reported as radioactivity (the measured concentration and a ± 2σ counting uncertainty) along with the detection limit or minimum detectable concentration (MDC). A measure concentration exhibiting a 2σ counting uncertainty greater than or equal to 100% is considered to be a nondetection. See Chapter 14.

a Sludge from LWRP digesters is dried before analysis. The resulting data indicate the plutonium concentration of the sludge prepared by LWRP workers for disposal at the Vasco Road Landfill in Alameda County.

b Because of the large number of nondetects, the central tendency is reported as less than the median value. See Chapter 14.

c IQR= Interquartile range

d Because of the large number of nondetects, the interquartile range is not calculated. See Chapter 14.

e 1 Ci = 3.7×10^{10} Bq

f Fraction of limit calculations are based on the annual total discharge for a given isotope and the corresponding concentration-based limit (0.56 and 0.37 Bq/mL for cesium-137 and plutonium-239, respectively) multiplied by the annual volume of Livermore site effluent.

g The DOE annualized discharge limit for application of best available technology (BAT) is five times the derived concentration guide (DCG: ingested water) for each radionuclide released.

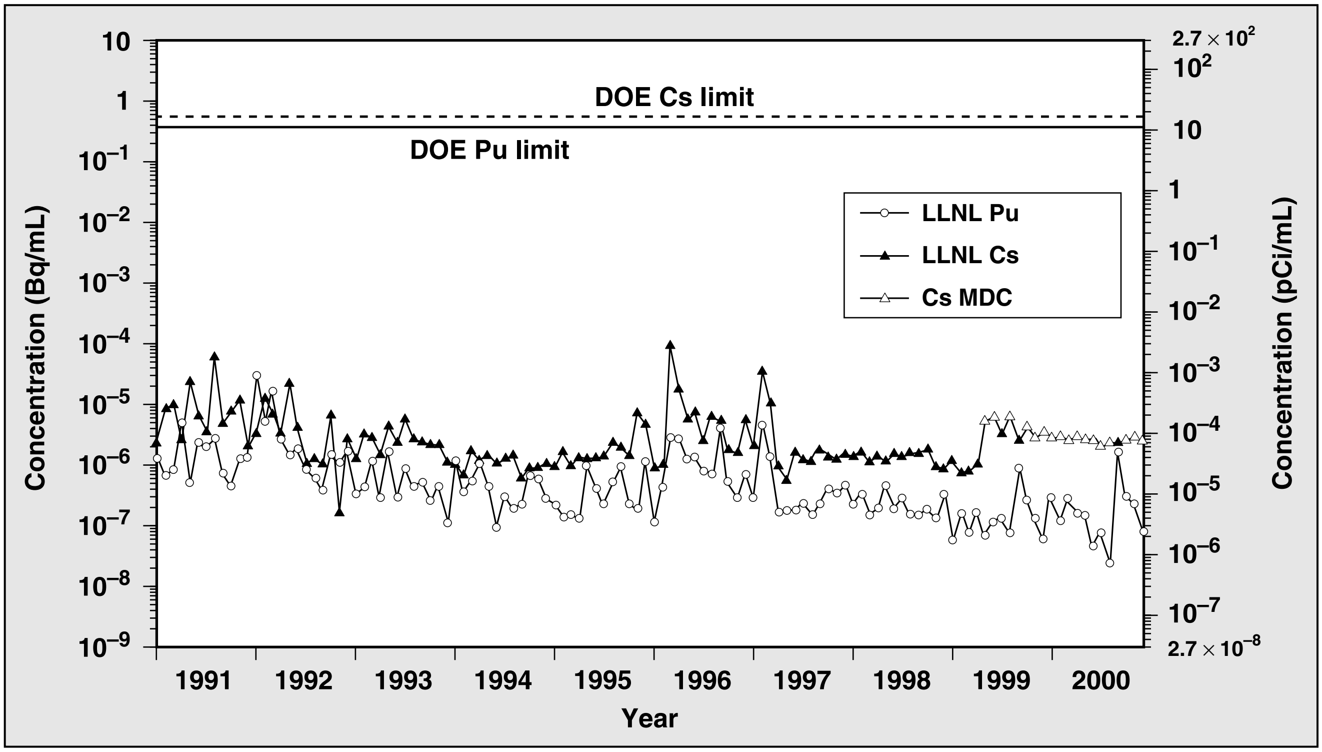

Figure 6-3. Historical trends in average monthly plutonium and cesium concentrations in LLNL sewage

The annual average concentration of cesium-137 was 4.6×10^{-6} (0.00046%) of the DOE DCG; and the annual average plutonium-239 concentration was 7.3×10^{-7} (0.000073%) of the plutonium-239 DOE DCG. These results are shown at the end of **Table 6-5**.

From 10 CFR 20, the numerical discharge limits for sanitary sewer discharges in the WSS include the annual discharge limits for radioactivity: 185 GBq (5 Ci) of tritium, 37 GBq (1 Ci) of carbon-14, and 37 GBq (1 Ci) of all other radionuclides combined.

The 10 CFR 20 limit on total tritium activity (185 GBq) dischargeable during a single year overrides the DOE Order 5400.5 concentration-based limit for tritium for facilities such as LLNL that generate wastewater in large volumes. In 2000, the total LLNL tritium release was 2.7% of this Title 10 limit. Total LLNL releases (see **Table 6-3**), in the form of alpha and beta emitters (excluding tritium), were 0.76% of the corresponding Title 10 limit.

In addition to the DOE average concentration discharge limit for tritium and the 10 CFR 20 annual total discharge limit for tritium, the LWRP established in 1999 an effluent concentration discharge limit for LLNL daily releases of tritium. This limit is more stringent than the DOE discharge limit: it is a factor of 30 smaller and applies to a daily rather than an annualized concentration. The maximum daily concentration for tritium in 2000 was 0.89% of the permit discharge limit. **Table 6-4** shows this result and the daily effluent discharge limit for tritium.

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 6-6** summarizes the radioactivity in liquid effluent released over the past 10 years. During 2000, a total of 5.0 GBq (0.14 Ci) of tritium was discharged to the sanitary sewer, an amount that is well within environmental protection standards and is comparable to the amounts reported since 1991. Moreover, the total tritium released by LLNL in 2000 continues the 1992 to 1999 trend of significantly smaller releases than those in the years prior to 1992.

Table 6-6. Radioactive liquid effluent releases from the Livermore site, 1991–2000

Year	Liquid effluent (GBq)	
	^3H	^{239}Pu
1991	32	6.1×10^{-4}
1992	8	1.9×10^{-3}
1993	13	2.6×10^{-4}
1994	6.9	1.9×10^{-4}
1995	6.0	1.2×10^{-4}
1996	12[a]	4.2×10^{-4}
1997	9.1	2.1×10^{-4}
1998	10	7.7×10^{-5}
1999	7.1	6.8×10^{-5}
2000	5.0	9.6×10^{-5}

a In 1995, Sandia National Laboratories/California ceased all tritium facility operations. Therefore, the annual tritium totals beginning with the 1996 value do not include contributions from Sandia/California.

Figure 6-3 summarizes the plutonium-239 monitoring data over the past 10 years. The historical levels observed since 1991 average 1 µBq/mL (3×10^{-5} pCi/mL). These historical levels generally are three-millionths (0.000003) of the DOE DCG for plutonium-239. The greatest part of the plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge, which is dried and disposed of at a landfill. The median plutonium concentration observed in 2000 sludge (**Table 6-5**), 0.17 mBq/dry g, is approximately 550 times lower than the EPA preliminary remediation goal for residential soil (93 mBq/dry g) and is nearly 2200 times lower than the remediation goal for industrial or commercial soil (370 mBq/dry g).

As first discussed in the *Environmental Report 1991* (Gallegos et al. 1992), plutonium and cesium concentrations were slightly elevated during 1991 and 1992 over the lowest values seen historically. As was established in 1991, the overall upward trend was related to sewer cleaning with new, more-effective equipment. The concentrations in 1996 and the first quarter of 1997 were also slightly higher than the lowest values seen historically, although slightly lower than those of 1990 through 1992. In fact, the cyclic nature of the data points in **Figure 6-3** suggests a potential frequency relationship in LLNL sewer lines for radionuclide buildup and subsequent liberation by line cleaning. The higher plutonium and cesium concentrations are all well below applicable DOE DCGs. In general, the plutonium and cesium concentrations for 2000 are comparable to the lowest values seen historically, and are well below the applicable DOE DCGs. (Note that because MDC values for cesium analysis increased in May 1999, most analytical results are below their respective MDCs; see **Table 6-5**.)

Nonradioactive Pollutants in Sewage

Monitoring Results

Table 6-7 presents monthly average concentrations for all regulated metals in LLNL's sanitary sewer effluent for 2000. The averages were obtained by a flow-proportional weighting of the analytical results for the weekly composite samples collected each month. Each result was weighted by the total flow volume for the period during which the sample was

Table 6-7. Average monthly results for regulated metals in LLNL sanitary sewer effluent (mg/L), 2000

Month	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Jan	0.011	0.0035	<0.0060	0.032	0.17	0.00032	0.0090	0.016	0.38
Feb	<0.010	0.0045	<0.010	0.023	0.19	0.00038	0.011	0.017	0.37
Mar	<0.010	0.0027	<0.0094	0.034	0.24	0.0013	0.012	0.031	0.60
Apr	<0.010	0.0047	<0.0057	0.057	0.19	0.00054	0.0090	0.027	0.35
May	<0.010	0.0072	<0.0059	0.13	0.33	0.00048	0.010	0.046	0.61
Jun	0.022	0.0065	<0.0053	0.13	0.48	0.00048	0.0042	0.042	0.71
Jul	0.022	0.0064	<0.0050	0.10	0.51	0.00015	0.026	0.048	0.79
Aug	<0.010	0.0055	<0.0050	0.062	0.30	0.00045	0.010	0.026	0.48
Sep	0.012	0.0050	<0.0050	0.098	0.51	0.00085	0.013	0.058	0.72
Oct	0.012	0.0086	<0.0050	0.15	0.52	0.0012	0.021	0.047	0.95
Nov	<0.010	0.0039	<0.0050	0.12	0.40	0.00081	0.011	0.031	0.74
Dec	<0.010	0.0020	<0.0071	0.040	0.22	0.00041	0.010	0.012	0.36
Median	<0.010	0.0049	<0.0055	0.080	0.32	0.00048	0.011	0.031	0.61
IQR[(a)]	—[(b)]	0.0026	—[(b)]	0.084	0.28	0.00042	0.0025	0.023	0.35
EPL[(c)]	0.2	0.06	0.14	0.62	1	0.01	0.61	0.2	3.0
Median fraction of EPL	<0.05	0.08	<0.04	0.13	0.32	0.05	0.020	0.16	0.20

Note: Monthly values are presented with less-than signs when all weekly composite sample results for the month are below the detectable concentration.

a IQR = Interquartile range

b Because of the large number of nondetects, the interquartile range cannot be calculated for these metals. See Chapter 14.

c Effluent pollutant limit (LLNL Wastewater Discharge Permit 1999–2000 and 2000-2001)

collected. The results are generally typical of the values seen from 1994 to 1999. **Figure 6-4** presents historical trends for the monthly 24-hour composite sample results from 1994 through 2000 for eight of the nine regulated metals; cadmium is not presented because this metal is typically not detected. Trends for chromium and copper continue to show the elevated average monthly concentrations observed in mid-1999, as compared with the previous years. The other metals have no discernible trends in their concentrations.

The concentrations measured in the routine analysis of LLNL sewage samples collected once a week (seven-day composite sample) and once a month (24-hour composite samples) are presented for eight of nine regulated metals as a percentage of the corresponding effluent pollutant limit (EPL) in **Figure 6-5**; cadmium is not present because it was detected in less than 5% of the samples, with a maximum detected value of no more than 4% of the discharge limit. The EPL is equal to the maximum pollutant concentration allowed per 24-hour composite sample, as specified by the LLNL wastewater discharge permit. When a weekly sample concentration is at or above 50%of its EPL, all daily (24-hour composite) samples collected in the SMS corresponding to the weekly sample period must be analyzed to determine if any of their concentrations are above the EPL. As

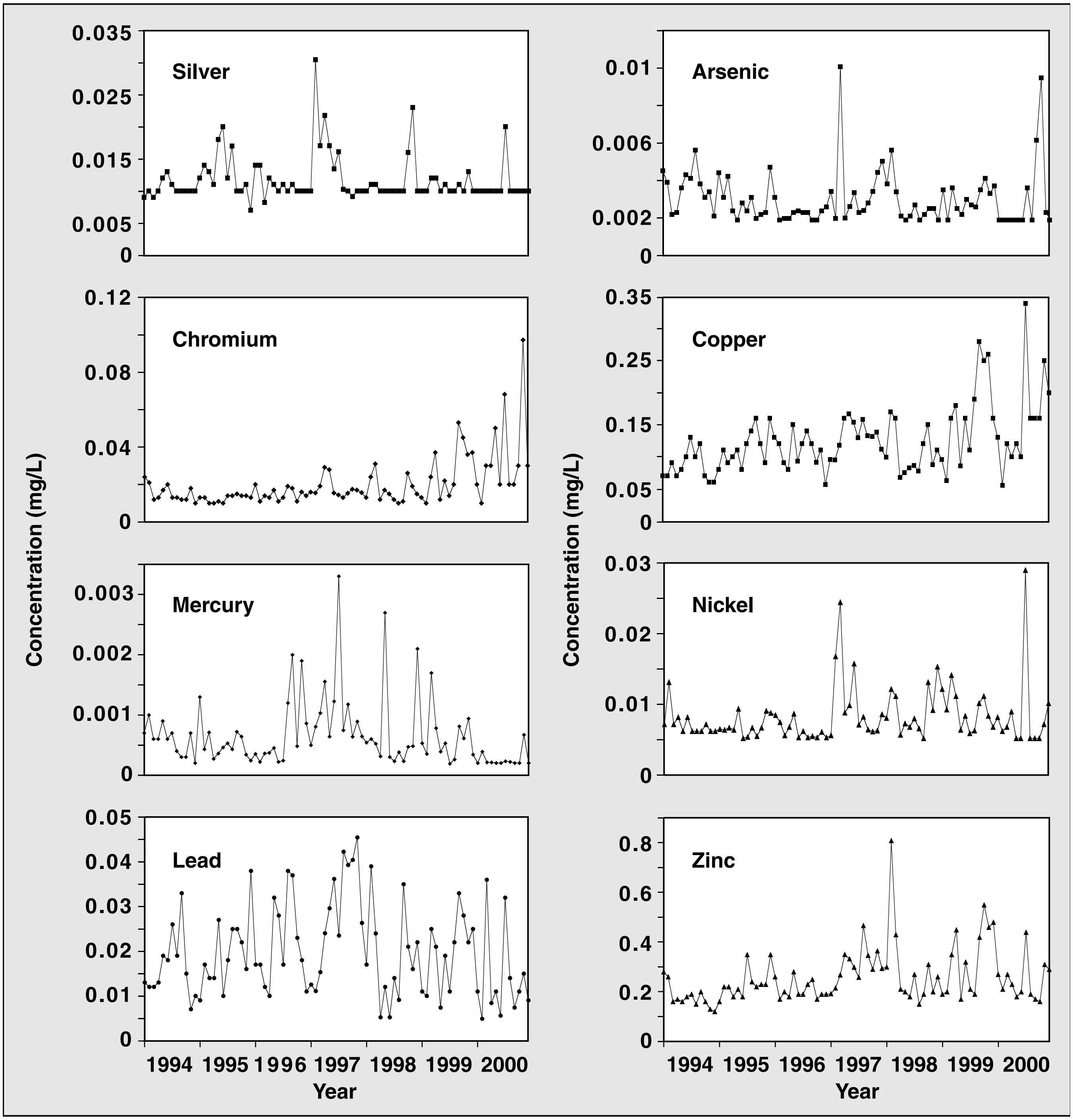

Figure 6-4. Monthly 24-hour composite sample concentrations for eight of the nine regulated metals in LLNL sanitary sewer effluent showing trends from 1994 to 2000

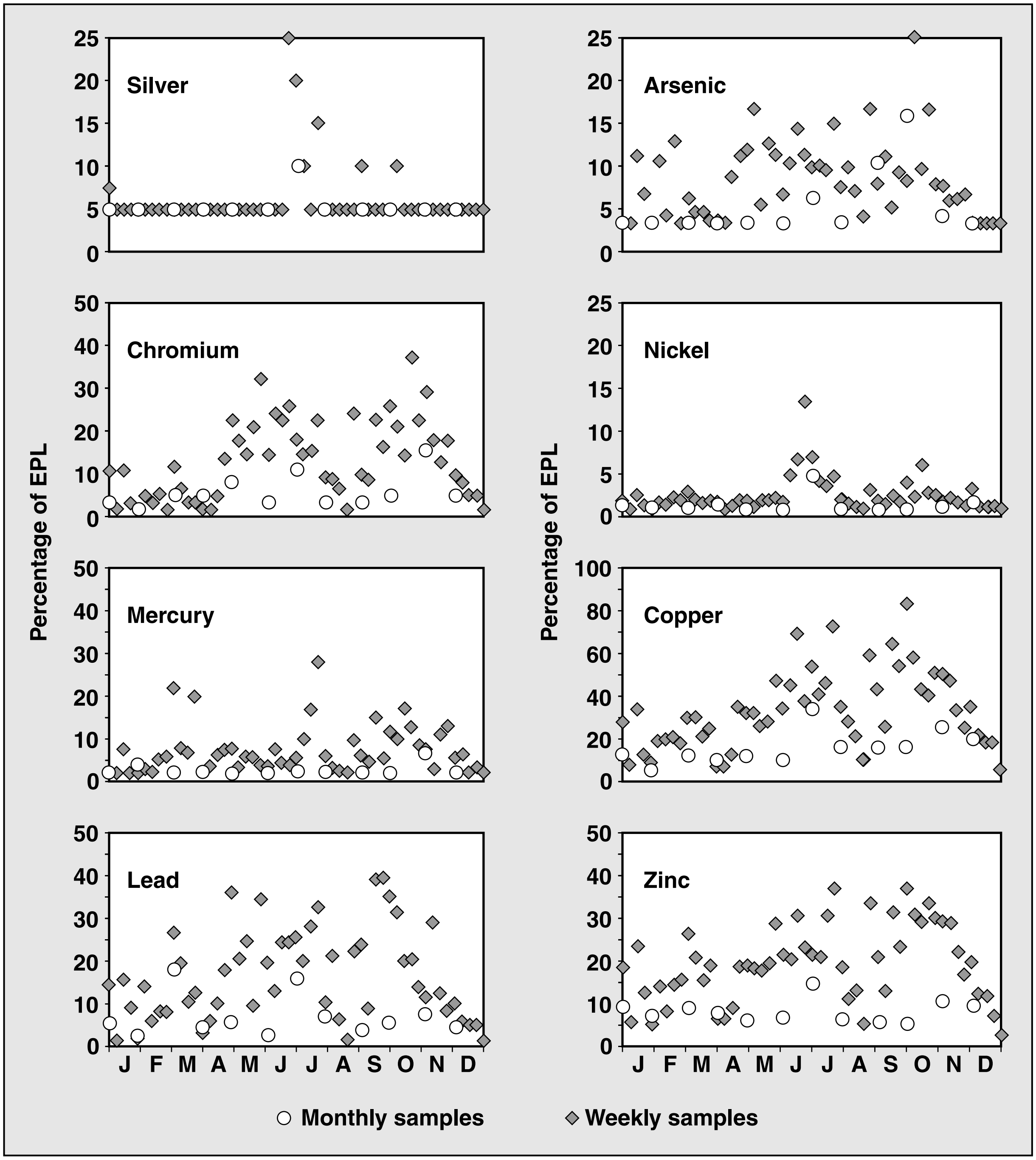

Figure 6-5. Results as percentages of effluent pollutant limits (EPLs) for eight of the nine regulated metals in LLNL sewage, 2000

discussed further in the "Environmental Impact" section, ten weekly sample concentrations met the action level in 2000, and no monthly sample concentrations were greater than the EPL.

Detections of anions, metals, and organic compounds and summary data concerning other physical and chemical characteristics of the sanitary sewer effluent are provided in **Table 6-8**. (All analytical results are provided in the Data Supplement, Table 6-7.) Although samples were analyzed for bromide, nitrite (as N), carbonate alkalinity (as $CaCO_3$), and hydroxide alkalinity (as $CaCO_3$), those analytes were not detected in any sample acquired during 2000, and so are not presented in **Table 6-8**. The results are quite typical of those seen in previous years except for the maximum cyanide concentration. See the "Environmental Impact" section for further discussion.

Environmental Impact

Table 6-7 presents monthly average concentrations and summary statistics for all regulated metals monitored in LLNL's sanitary sewer effluent. At the bottom of the table, the annual median concentration for each metal is compared with the discharge limit. In 2000, the metals closest to the discharge limits were copper, zinc, and lead at 32%, 20%, and 16%, respectively.

Although monthly 24-hour composite sample results for chromium and copper have been slightly elevated since 1999 (see **Figure 6-4**), all of the individual weekly and monthly results for 2000 were less than 50% of the corresponding discharge limits, except for ten weekly concentrations. The daily samples that correspond to the appropriate weekly composite sampling periods were submitted for analysis. All of the analytical results for the daily samples were less than the effluent pollutant limit; no sample had a copper concentration greater than 0.35 mg/L.

Table 6-8 presents summary results and statistics for monthly monitoring of physical and chemical characteristics of LLNL's sanitary sewer effluent. Although the results are generally similar to typical values seen in previous years for both the three regulated parameters (total toxic organics [TTO], cyanide, and oil and grease) and all other nonregulated parameters, there is one notable exception in the maximum value shown for cyanide.

The January 2000 semiannual compliance grab sample that was analyzed for cyanide had a concentration of 0.051 mg/L. The LWRP issued an NOV to LLNL for this result because it exceeded the discharge limit of 0.04 mg/L. Subsequent sampling performed in March demonstrated a return to compliance with a concentration of <0.020 mg/L. No corrective actions were required.

In 2000, the SMS continuous monitoring system detected two inadvertent discharges: one for pH and the other for silver. (For comparison, 4, 2, and 13 such diversions occurred in 1999, 1998, and 1997, respectively.) Neither incident represented a threat to the integrity of the operations at the LWRP. (Uncontained pH and metals releases of sufficient concentration and duration outside the effluent pollutant limit range could disrupt treatment plant operations or cause the treated wastewater to exceed allowable concentration limits for discharge to the San Francisco Bay.) On July 28, 2000, the release of a caustic contaminant raised the pH of the LLNL effluent above the permitted value of 10 for 11 minutes during which the maximum pH was 11.3. The incident was not considered an enforceable exceedance of permit conditions because it did not exceed the duration criteria of 40 CFR 401.17. The event was of sufficient concentration and duration to warrant a sewage diversion, although not all effluent was captured because of a pHMS controller error (see the "Monitoring" section of this chapter); of the

Table 6-8. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 2000[(a)]

	Detection frequency[(b)]	Minimum	Maximum	Median	IQR[(c)]
24-hour composite sample parameter (mg/L)					
Alkalinity					
Bicarbonate alkalinity (as $CaCO_3$)	12/12	115	241	210	33
Total alkalinity (as $CaCO_3$)	12/12	115	241	210	38
Anions					
Bromide	3/12	<0.1	0.4	<0.1	—[(d)]
Chloride	12/12	17	87	46	24
Fluoride	9/12	<0.050	0.28	0.068	0.05
Orthophosphate	12/12	0.90	20	16	4.3
Sulfate	12/12	5.9	16	9.5	3.3
Nutrients					
Ammonia nitrogen (as N)	12/12	20	56	40	14
Total Kjeldahl nitrogen	12/12	28	90	56	6
Total phosphorus (as P)	12/12	5.4	9.9	8.3	1.8
Oxygen demand					
Biochemical oxygen demand	12/12	88	760	223	111
Chemical oxygen demand	12/12	260	910	486	208
Solids					
Total dissolved solids	12/12	183	367	233	45
Total suspended solids	12/12	91	450	252	244
Volatile solids	12/12	74	474	220	257
Total metals					
Calcium	12/12	9.2	30	14	7.3
Magnesium	12/12	2.1	3.7	2.5	0.83
Potassium	12/12	12	22	18	3.5
Total organic carbon	12/12	41	72	55	20
Tributyltin (ng/L)[(f)]	2/2	40	250	145	—[(d)]

Table 6-8. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 2000[(a)] (continued)

	Detection frequency[(b)]	Minimum	Maximum	Median	IQR[(c)]
Grab sample parameter					
Semivolatile organic compounds (μg/L)					
Benzoic acid	6/12	<10	120	25	—[(d)]
Benzyl alcohol	10/12	<2.0	32	6.5	—[(d)]
Bis(2-ethylhexyl)phthalate[(e)]	10/12	<5.0	93	13	7
Butyl benzyl phthalate[(e)]	2/12	<2.0	20	2.0	—[(d)]
Diethylphthalate	11/12	4.2	22	12	8.4
m- and p- Cresol	9/12	<2.0	60	13	22
Total cyanide (mg/L)[(f)]	2/3	<0.02	<0.051[(g)]	0.030	—[(d)]
Oil and grease (mg/L)[(f)]	2/2	11	17	14	—[(d)]
Volatile organic compounds (μg/L)					
1,4-Dichlorobenzene	8/12	<0.50	1.1	0.62	0.24
Acetone	12/12	74	550	145	183
Chloroform	12/12	5.1	15	12	4.6
Ethanol	3/12	<1000	<4100	<1000	—[(d)]
Toluene	6/12	<0.50	<1.5	<0.50	—[(d)]

a The monthly sample results plotted in **Figures 6-5** and nondetected values reported in the Data Supplement, Chapter 6, are not reported in this table.

b The number of times an analyte was positively identified, followed by the number of samples that were analyzed (generally 12, one sample for each month of the year).

c IQR = Interquartile range

d When the detection frequency is less than or equal to 50%, there is no range, or there are less than four results for a sample parameter, the interquartile range is omitted.

e Priority toxic pollutant parameter used in assessing compliance with the total toxic organic (TTO) permit limit of 1 mg/L (1000 μg/L) issued by the Livermore Water Reclamation Plant.

f Sampling for this parameter is required on a semiannual rather than a monthly basis. An additional cyanide sample was taken in March to demonstrate return to compliance.

g See the "Environmental Impact" subsection of the "Nonradioactive Pollutants in Sewage" section for a discussion of this result.

approximately 17,000 L of effluent with pH greater than 10, about 7600 L were captured. Subsequent analysis of all diverted effluent showed that the average pH was acceptable for release of the wastewater back to the sanitary sewer.

In the case of a June 26, 2000, inadvertent discharge of silver detected by the SMS, the LWRP issued an NOV for an excess of silver (0.31 mg/L) in the daily composite sample. The discharge permit limit is 0.2 mg/L. This incident initiated a ten-minute diversion during which approximately 8000 L of effluent were contained by the SDF. The diverted effluent was shipped off site for disposal.

Unlike 1999, monitoring results for 2000 did not reflect a perfect year for LLNL's sewerable water discharge control program and Livermore site personnel. Nonetheless, LLNL achieved greater than 99% compliance with the provisions of its wastewater discharge permit.